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Inland Waters Directorate
Western and Northern Region

Direction générale des eaux intérieures
Région de l'ouest et du nord

PLANNING FOR HYDROLOGIC DROUGHT:

A DISCUSSION OF OPTIONS

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ABSTRACT

Canada's southern prairies have had below normal surface water conditions for much of the past decade. During the same period, water demands for instream and withdrawal uses have risen. The frequent inability of supplies to satisfy demands has seriously disrupted both the economy and the environment. Hardships caused by droughts indicate that a better balance between demand for and supply of the region's limited water resources must be reached.

This paper examines alternative non-structural and structural measures which do or can contribute to sustainable use of water in the semiarid southern prairies. Particular attention will be given to long-term measures that reduce the growth rate of water demands, increase the efficiency of existing use, enhance water supplies and increase awareness of the value of water.

RÉSUMÉ

La région du sud des Prairies canadiennes a connu un apport d'eau superficielle inférieur à la normale pendant la majeure partie de la dernière décennie. Pendant cette même période, la demande d'eau dans les cours d'eau et pour prélèvement s'est accrue. L'impossibilité fréquente de satisfaire la demande a sérieusement perturbé l'économie et l'environnement. Les difficultés causées par les sécheresses montrent qu'il est indispensable d'atteindre un meilleur équilibre entre la demande d'eau et les ressources hydriques limitées de la région.

Dans le présent rapport, nous examinons des mesures structurales et non structurales qui contribuent ou peuvent contribuer à maintenir un niveau soutenu d'utilisation de l'eau dans la région semi-aride du sud des Prairies. Nous prêterons une attention particulière aux mesures à long terme visant à freiner la

croissance de la demande d'eau, à accroître l'efficacité de l'utilisation actuelle de l'eau, à améliorer les ressources hydriques et à rendre la population plus consciente de la valeur de l'eau.

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1.0 INTRODUCTION

1.1 What is the Problem?

Hydrologic droughts constrain water development and use, especially in the semiarid Canadian prairies where water supply is extremely variable. Long-term hydrometric records for the Bow River at Calgary and the Assiniboine River near the Saskatchewan-Manitoba border illustrate this variability. (Figures 1,2) The margin between supply and demand is often small, even under normal conditions. Droughts further reduce that margin, causing economic output to decline and user conflicts to increase.

In the face of growing water demands (Figure 3) and rising economic and environmental costs associated with traditional strategies to increase supply, new approaches to water management are needed. Failure to adequately respond to this challenge will jeopardize the sustainablility of our water resources.

1.2 What are the Solutions?

The principle of sustainable water resources development is supported in numerous recent high profile documents. The **Report of the National Task Force on Environment and Economy** (1987), the **Federal Water Policy** (1987), **Water 2020 - Sustainable Use for Water in the 21st Century** (1988) and provincial/territorial conservation strategies all strongly promote long-term planning and management in support of sustainable development. They call for an integrated multisectoral approach and closer cooperation among all parties. A balance between water demand and supply must be reached, during droughts as well as during normal or above

Figure 1: BOW RIVER AT CALGARY

NATURAL FLOW

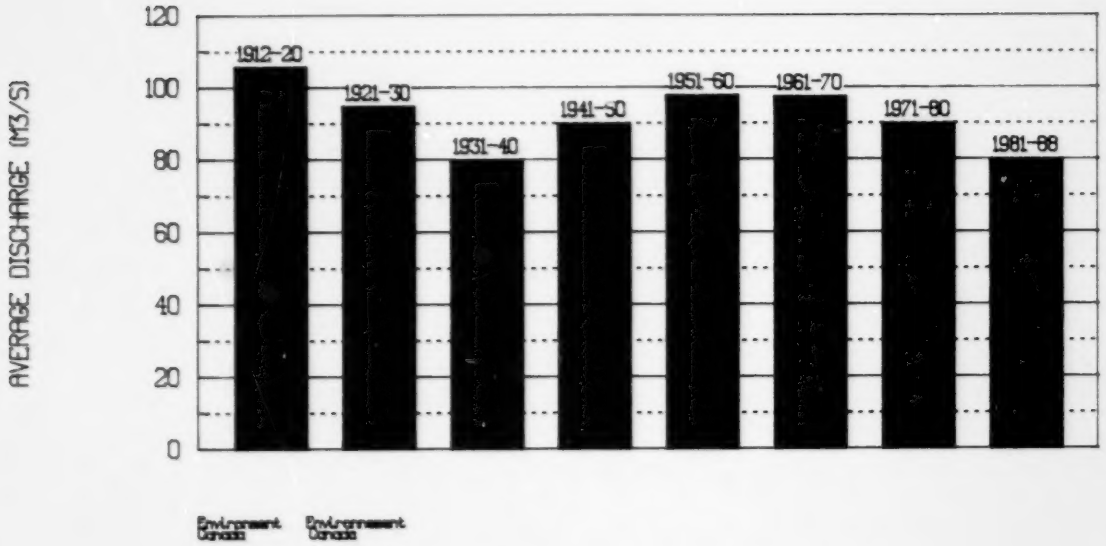


Figure 2: ASSINIBOINE RIVER NEAR THE MANITOBA BOUNDARY

NATURAL FLOW

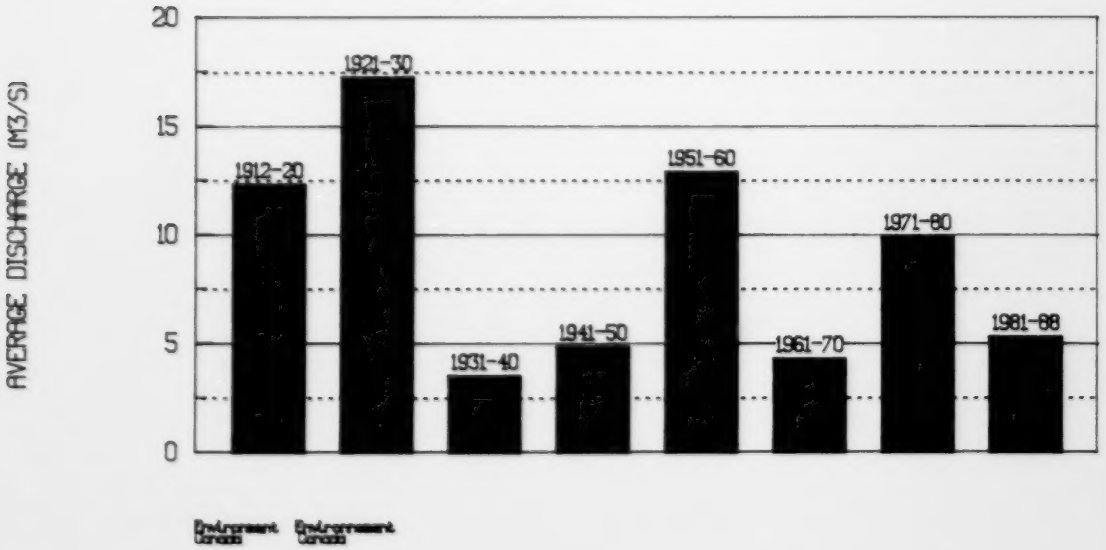
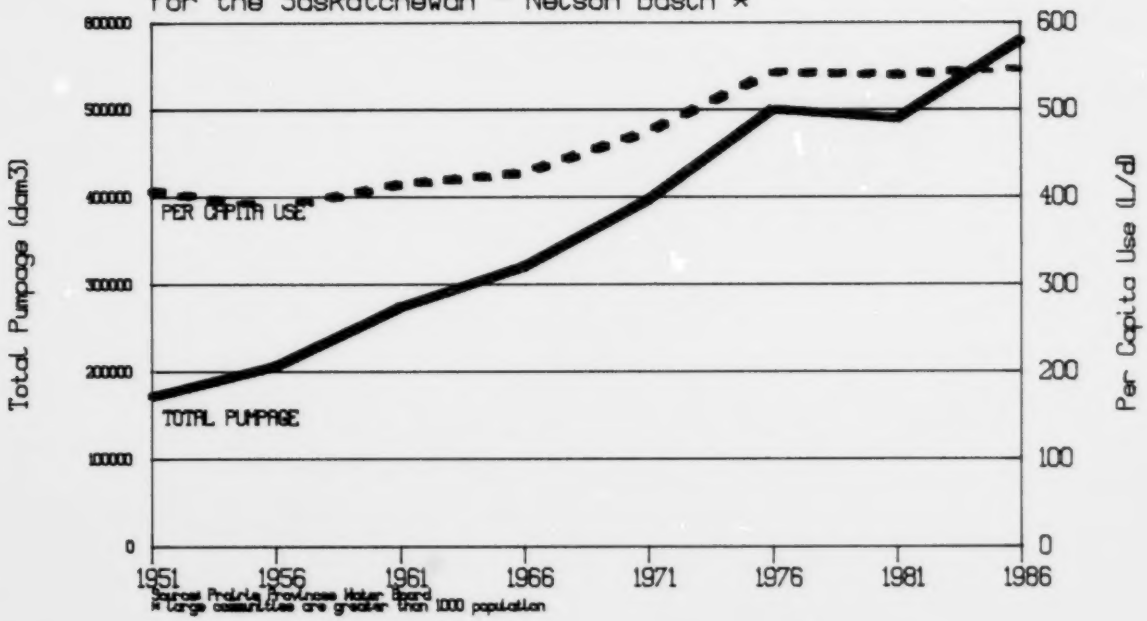


Figure 3: Large Community Water Use
for the Saskatchewan - Nelson Basin *



normal conditions, if options for future use are to be preserved and sustainablilty achieved.

This presentation deals with measures to prevent or reduce the impact of hydrologic drought in the Canadian prairies. Emphasis is placed on long-term measures. For the purposes of this paper, hydrologic drought is defined as a sustained period of below normal natural stream flows, lake levels or ground water levels which results in insufficient water to meet established needs.

2.0 WATER MANAGEMENT IN THE CANADIAN PRAIRIES

Responsilility for water resources management is shared by the three levels of government. As owners of the water resource, provinces have lead responsibility for its management. Federal jurisdiction is more limited. Interjurisdictional waters, federal lands, fisheries, migratory birds and navigation are the major areas of federal interest. Other areas include scientific research, data collection and public information. Municipal governments are mainly responsible for the supply and treatment of water and sewage.

3.0 DROUGHT IMPACTS

3.1 Biophysical

The prairie ecosystem evolved under fluctuating wet and dry conditions. Drought was an important element in maintaining long-term productivity. Human activity has radically altered the environment, however, and imbalances in the ecosystem have

resulted. Drought conditions now place a greater strain upon the present environment.

Low water levels and flows are directly associated with reduced water quality. Changes can include increased temperature, decreased dissolved oxygen content, greater weed and algae growth and higher concentrations of contaminants, such as nutrients and dissolved salts. Municipal and industrial pollutants and agricultural runoff increase problems caused by low flows. Reduced quality seriously limits the ability to maintain aquatic life.

Wildlife, including fish, can be affected by below normal water levels and associated reduced quality. A positive correlation exists between pond numbers and breeding mallard populations. (Figure 4) Wetland habitat can be more easily changed by drainage, cultivation or burning during droughts. What was a temporary displacement under natural conditions can now be a permanent loss of habitat. Further, the beneficial aspect of drought upon wetland productivity is lost when wetlands are altered. Increased fish kills, reduced reproduction and lower growth rates can occur.

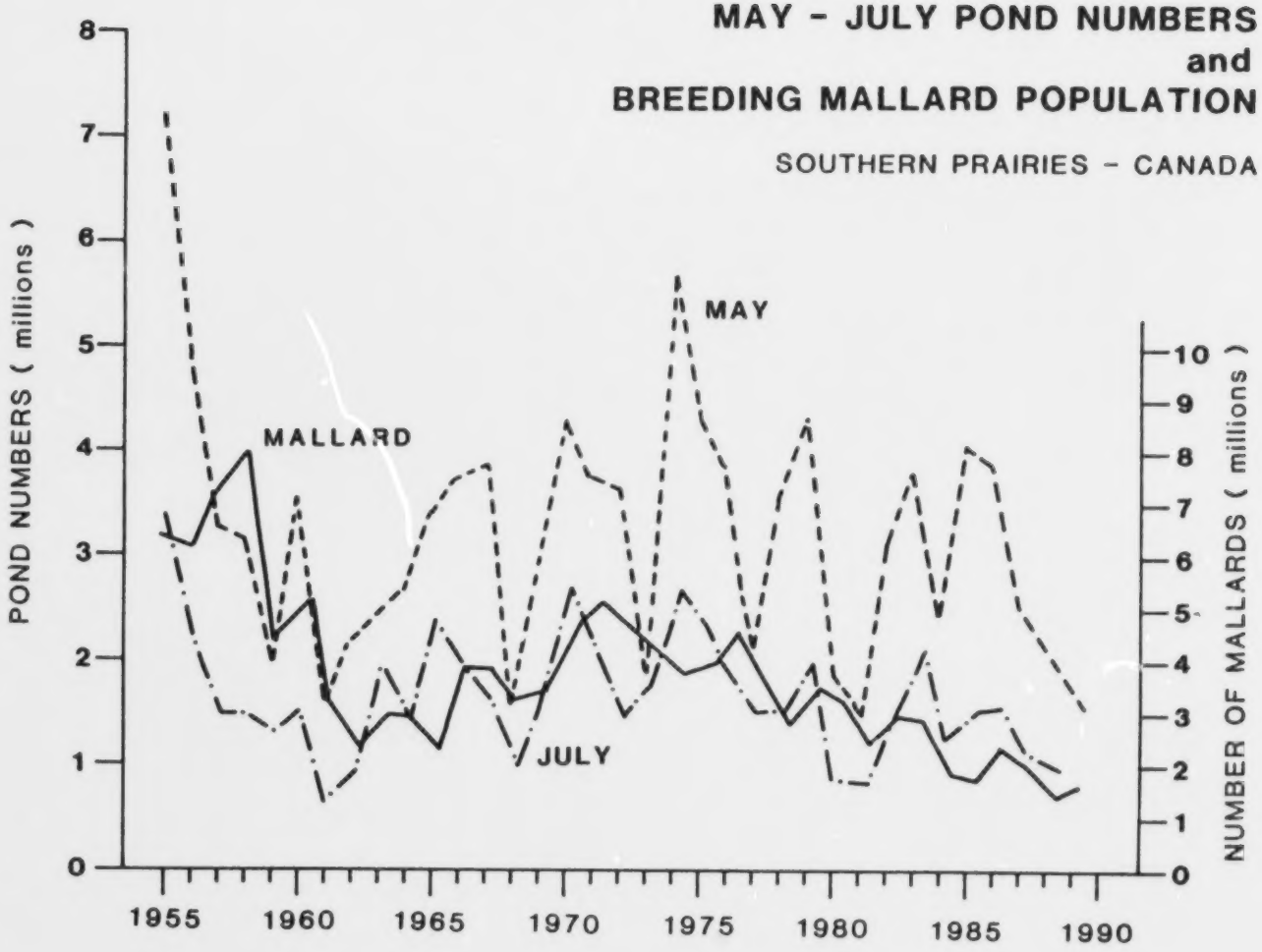
3.2 Socioeconomic

Water supplies of desirable quality are often inadequate to meet established needs during hydrologic droughts. This can result in far-reaching effects upon local, regional and sometimes national economies. The degree and nature of impact is due partly to the physical extent, duration and severity of the drought but also to societal conditions. Furthermore, each sector is affected differently by drought. Indirect costs to society, as a result of reduced economic output in primary sectors such as agriculture and hydropower, outweigh direct costs.

Figure 4

MAY - JULY POND NUMBERS and BREEDING MALLARD POPULATION

SOUTHERN PRAIRIES - CANADA



Source: Canadian Wildlife Service
Environment Canada.

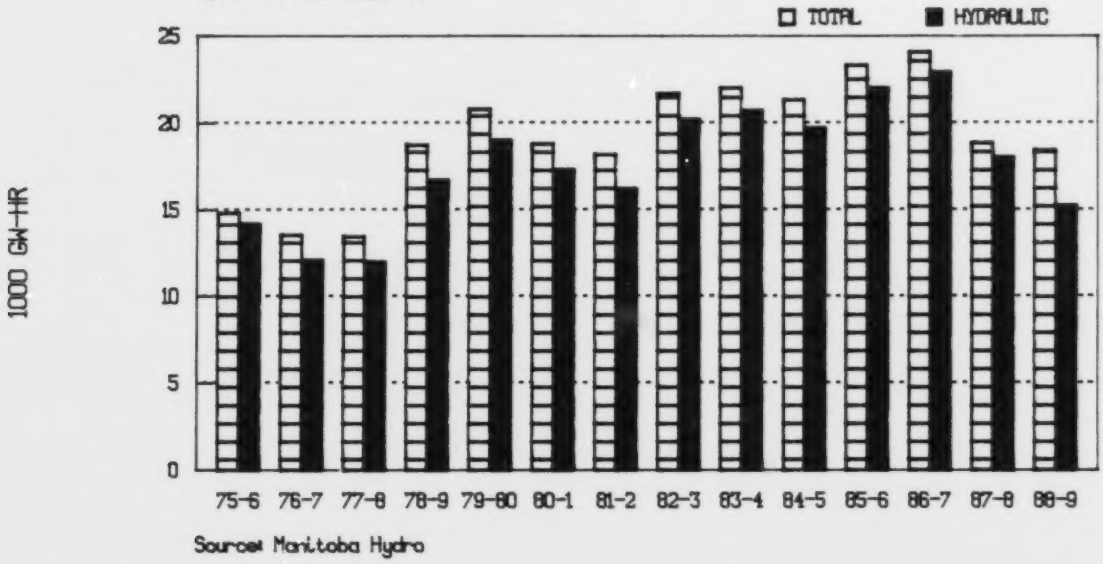
AGRICULTURE - Prairie farmers are dependent upon stable supplies of water for domestic needs, livestock and irrigation. Many have constructed dugouts and dams to store surface runoff or have constructed wells. During droughts, when runoff can be zero, the previous year's runoff and ground water are of critical importance to the regional farm economy. Reduced crop and pasture yields are the most important result of drought in the prairies. In addition, livestock farmers have been forced to reduce herd size when water supplies are insufficient.

MUNICIPAL - Urban residents, though not so directly affected by climatic forces as farmers, have also had to curtail water use in times of drought. Shortages result either from the inability of the water supply and treatment system to meet increased demands or the reliability of the water source itself. Water quality, in addition to supply, is a very real concern to municipal users during drought. Additional costs are incurred to treat both the drinking water supply and the sewage.

ELECTRICAL POWER - Below normal water levels seriously affect the production of electricity. Of the three prairie provinces, Manitoba's power industry is most dependent upon stable or high water levels or flows. (Figure 5) Lower electrical production means higher production costs and lower profits. Higher rates for consumers and possibly "brown outs" can result if drought persists.

Figure 5: MANITOBA POWER PRODUCTION

1975-76 to 1988-89



Source: Manitoba Hydro

RECREATION - Outdoor recreation is affected by hydrologic drought in a variety of ways. Low water levels or flows and associated poor quality reduce opportunities for activities, such as swimming and boating. Reduced populations of fish, waterfowl and other wildlife limit opportunities for fishing and hunting and detract from the general enjoyment of an outdoor recreational experience. Warm sunny weather, which often accompanies droughts, partially offsets unattractive water conditions. Increased use could actually result.

4.0 DROUGHT PREVENTION AND MITIGATION

Long-term integrated planning is required to minimize adverse effects of drought upon the economy and the environment. Data collection, impact assessment and research are fundamental to the development of effective response measures, whether they be traditional supply oriented measures or demand management measures. An effective communication system linking all involved parties is necessary if drought impacts are to be prevented or mitigated and resources used efficiently.

4.1 Data Collection and Monitoring

Drought management depends on a scientifically sound knowledge base developed in cooperation with all responsible agencies. Data on numerous aspects of the water resource, its use and factors which affect its biophysical characteristics are required. Effective efficient data collection and monitoring programs provide reliable, timely, accessible and user specific information. A variety of data collection techniques, including surface-based instruments, remote sensing, on-site inspection and personal communication are needed to collect the different kinds of data required for

various purposes. Information on current conditions and long-term trends assists managers to make timely decisions to protect the environment, conserve scarce resources and minimize social and economic disruption.

4.2 Drought Impact Assessment

Impact assessment leads to an understanding of the linkages between below normal water supply, quality and use and the effects that droughts have on both the environment and the economy. As a result, improved long and short-term response measures can be developed to prevent or mitigate adverse impacts.

Two main categories of drought impact assessment are:

- monitoring impacts of ongoing droughts in near real time and
- evaluating past, present and future droughts.

The first category is used primarily for drought detection and early warning. The second category documents the full array of drought-related impacts. Techniques used include both empirical documentation of impacts of past and current droughts and computer aided simulation of future droughts.

4.3 Research and Development

Drought problems involve a complex integration of environmental and economic components. Drought research, no less than other scientific research, requires an interdisciplinary approach and a long-term commitment of resources. Continued research and development is necessary to achieve an improved understanding of drought causes and consequences. Fully understanding these areas of concern is a prerequisite to anticipating and preventing drought impacts. To be most effective in influencing decisions, research

findings must be responsive to policy and applied science needs and be widely disseminated to the public.

Many potential areas for drought research exist. One of the most critical, however, is the need to determine the economic and social value of water for future uses. This is fundamental to achieving sustainability. Research into mechanisms for conflict resolution among water uses is becoming increasingly necessary as demand for scarce resources increases. A third area requiring research is in the development of tools which aid in drought impact prevention. Remote sensing techniques which provide early warning information in real time require further development. Long range weather forecasting is another area of endeavour which should be pursued. Existing models designed to improve drought response prediction must be refined both in terms of data and assumptions on which they are based. Technological development aimed at increasing water use efficiency for municipal, industrial and agricultural purposes would be of particular benefit to drought managers.

4.4 Adjustment and Response Measures

The best time to prepare for drought is when no drought exists. In this way a well thought out response plan can be developed. Governments can then respond quickly and effectively when conditions reach predetermined stages.

The traditional response has been to enhance water supplies through the construction of dams, diversions, pipelines, wells and other water development projects. Rising economic and environmental costs associated with traditional water supply strategies, together with increasing competition for limited supplies, require a new approach to water management. Greater

use of demand oriented measures must be employed in the future.

Drought adjustment and response measures can alter water use in the long or short term. Examples of long-term measures designed to reduce demand are realistic pricing, regulation, incentives, recycling and reuse, substitution, increased efficiency and energy conservation. Mandatory or voluntary use restrictions are the most common form of short-term reactive demand management measures. Reuse, scheduling, surcharges, small scale retrofits and conservation of electricity are other short-term measures. Table 1 provides more detail on these measures.

Long-term supply management measures include construction of water storage projects, vegetation management, wetland retention, ground water management and water quality improvement. In the short term, water supplies can be enhanced through emergency pumping or hauling, reuse, more effective use of precipitation, ground water use, changes to reservoir operation and reduction of evapotranspiration. Table 2 provides a more detailed list of supply management measures.

Education and information programs, water audits and licensing are measures applicable to all categories.

Table 1

DEMAND MANAGEMENT ADJUSTMENT AND RESPONSE MEASURES

CONTINUOUS	SHORT-TERM	LONG-TERM

- education
- public info
- technical info (demonstrations)
- water audits (data collection)
- licensing, allocation
	- mandatory and voluntary restrictions
	  - rationing
	  - time of use
	  - pressure reduction
	- reuse
	  - grey water irrigation
	- scheduling
	- water use surcharge
	- retrofit (small scale)
	- electrical restrictions/conservation
		- user pay
		  - rate adjustment plus metering
		- regulation
		  - building and plumbing codes
		  - outdoor codes
		  - fines for over use
		- financial incentives
		  - subsidies, grants, rebates
		  - low interest loans
		  - higher prices
		- recycling and reuse
		  - treatment
		  - sewage irrigation
		- substitution
		  - air cooled
		  - desertscaping
		- increased efficiency
		  - improve distribution
		  - improve application types/timing
		- energy efficiency
		  - conserve energy for heating/pumping
		- recycle products
		  - paper
		  - steel

Table 2

SUPPLY MANAGEMENT ADJUSTMENT AND RESPONSE MEASURES

CONTINUOUS	SHORT-TERM	LONG-TERM

- education
- public info
- technical info
- technology transfer
- water audit (data collection)
- licensing, allocation
	- emergency supply
	  - pumping
	  - hauling
	- reuse
	  - use sewage for fire control
	- precipitation
	  - snow management
	  - collect rain water
	- ground water use
	  - mix surface/ground water
	  - freeze treatment
	- change reservoir operation
	  - reduce releases
	- reduce evapotranspiration
	  - remove hydrophytic vegetation along waterways
		- project construction/ reconstruction
		  - dams
		  - pipelines
		  - diversions
		  - dugouts
		  - wells
		- vegetation management
		  - forest management
		- wetland retention
		- ground water management
		  - aquifer construction
		  - conjunctive use
		  - recharge
		- water quality improvement
		  - desalination
		  - sewage reuse

4.5 Institutional Response

The coordination of drought planning and response, both during and between droughts, is essential. This is because of the wide cross-section of society which is affected and the diversity of public and private agencies with responsibility for management and use of our water resources. As stated in the **Report of the National Task Force on Environment and Economy**, (1987) "The principles of shared responsibility and integrated decision making must become the foundation for our institutions and guide our key decision makers." By changing institutional processes, it follows that the outcome may also change.

Mechanisms which foster coordination and cooperation range from formal agreements to interagency task forces and committees and communication networks.

4.6 Communication

Effective communication among all parties is an essential component of drought planning and response. The term "communication" implies not only the provision of information but also the sharing of ideas and opinions. A communications plan should be developed to provide for the orderly flow of technical data and information in a format suitable for intended users, the dissemination of real time data during drought events and opportunities for exchange of information and ideas among professionals from various fields. In Canada, shared jurisdiction over water resources makes communication among and within governments particularly important.

Public information and education programs can alter user attitudes and consumption patterns in both the long and short term. Programs must be responsive to the needs of the public,

however, as information needs change during the course of a drought and between droughts. Furthermore, different types of users require different kinds of information. Users should be given opportunities to make their needs known.

5.0 CONCLUSION

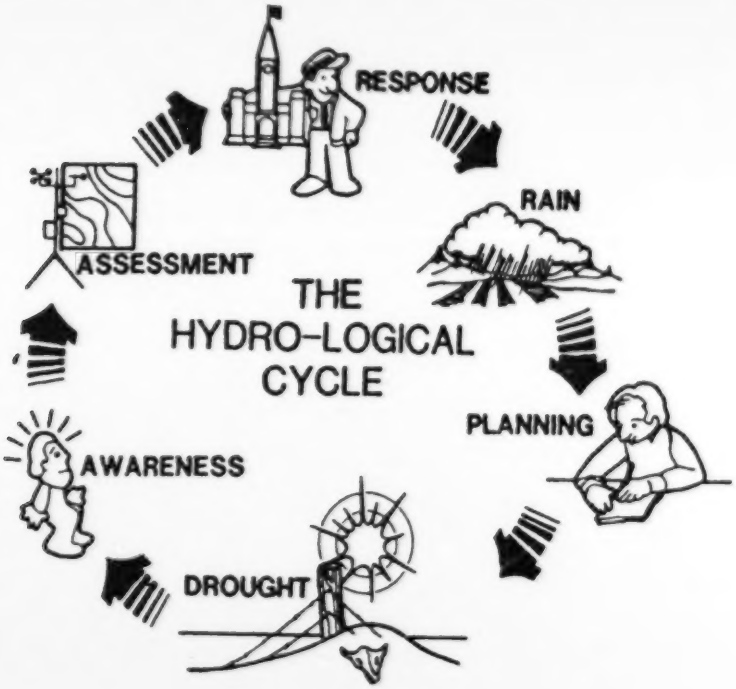
Periodic dry spells are a natural feature of the semiarid Canadian prairies. Though we cannot predict exactly when or where below normal water supply conditions might happen, we can calculate the probability of drought occurrence. With rational action based on careful planning we can learn to live with drought. (Figure 6)

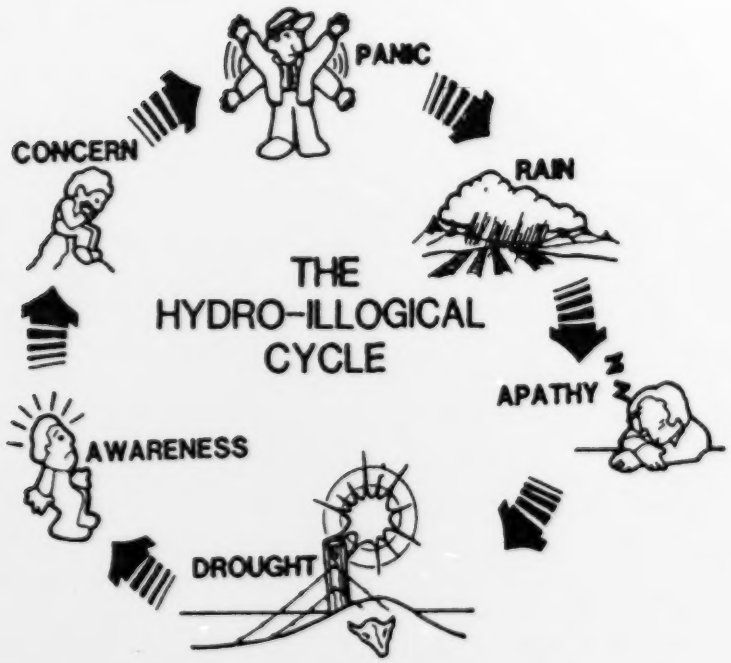
Long-term planning for drought is essential to minimize adverse impacts to both the environment and the economy. Planning must be carried on through both wet and dry cycles. Management by crisis is inefficent and can actually increase vulnerability to drought over the long-term.

Achieving and maintaining a sustainable level of water use requires a balance between supply and demand oriented measures. Limiting water use to conform to existing supplies through appropriate economic development, technological advances, conservation measures, financial incentives, education and changes to government policies and institutions is the objective of demand management.

The complex interdisciplinary nature of drought requires that it be dealt with in an integrated manner. Physical, biological and social scientists must work closely with engineers, water planners, managers and users to resolve problems. With so many parties involved, effective communication is essential.

Figure 6





Source: Adapted from Wilhite (1986)

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